

Coaxial wet-spun fibers loaded with essential oils for the treatment of chronic wounds

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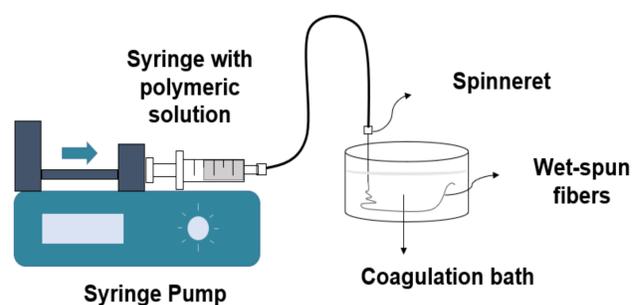
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Introduction

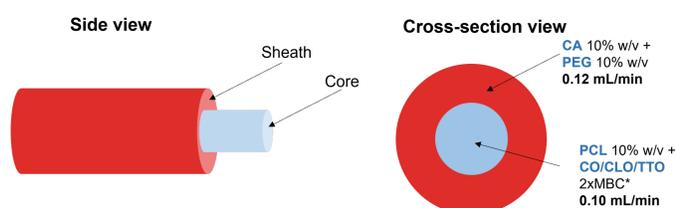
Chronic wounds (CWs) can greatly impact the health and quality of the patients' lives. The excessive use of antibiotics has led to a significant development of antibiotic-resistant microorganisms, making it crucial to think of alternative solutions. Considering these issues, a drug delivery system made of coaxial wet-spun fibers loaded with essential oils (EOs) was proposed. Coaxial structures were produced using the wet-spinning technique, in which polycaprolactone (PCL - a synthetic polymer with excellent mechanical properties and elastic behavior) solution was loaded at the core and mixed with three EOs – Clove Oil (CO), Cinnamon Leaf Oil (CLO) and Tea Tree Oil (TTO). The shell was composed of a blend of cellulose acetate (CA - a natural polymer which has been reported to offer good structural integrity) solution, mixed with polyethylene glycol (PEG - a synthetic polymer endowed with high elasticity and porosity), so pores could be opened in the outer layer, allowing for a sustained release of the EOs loaded at the fibers' core. Physical, chemical, thermal and biological characterizations were performed. Results confirmed the potential of the engineered coaxial wet-spun fibers for wound healing applications. Still, further characterization on the fibers is necessary, including cytocompatibility tests to assure non-toxic profiles of the fibers when in contact with fibroblasts and keratinocytes.

Wet-spinning

Technique based on a non-solvent-induced phase inversion process, including a polymeric solution extrusion into a coagulation bath composed by a poor solvent or a non-solvent/solvent mixture to form a coagulating filament that will solidify as a continuous polymeric fiber.



Coaxial wet-spun fibers



Goal of Each Microfiber Component:
CA: generate porosity and maintain fibers' structural integrity
CO/CLO/TTO: antimicrobial activity
PEG: provide elasticity to the fibers
PCL: maintain fibers' structural integrity

*MBC: Minimum Bactericidal Concentration

Produced fibers:

- CA hollow (core: coagulation bath; shell: CA);
- CA-PEG hollow (core: coagulation bath; shell: CA combined with PEG);
- PCL (core: PCL; shell: coagulation bath);
- PCL-CO/CLO/TTO (core: PCL combined with CO/CLO/TTO; shell: coagulation bath);
- PCL-CA (core: PCL; shell: CA);
- PCL-CO/CLO/TTO-CA (core: PCL combined with CO/CLO/TTO; shell: CA);
- PCL-CA-PEG (core: PCL; shell: CA combined with PEG);
- PCL-CO/CLO/TTO-CA-PEG (core: PCL combined with CO/CLO/TTO; shell: CA combined with PEG).

Fibers morphology

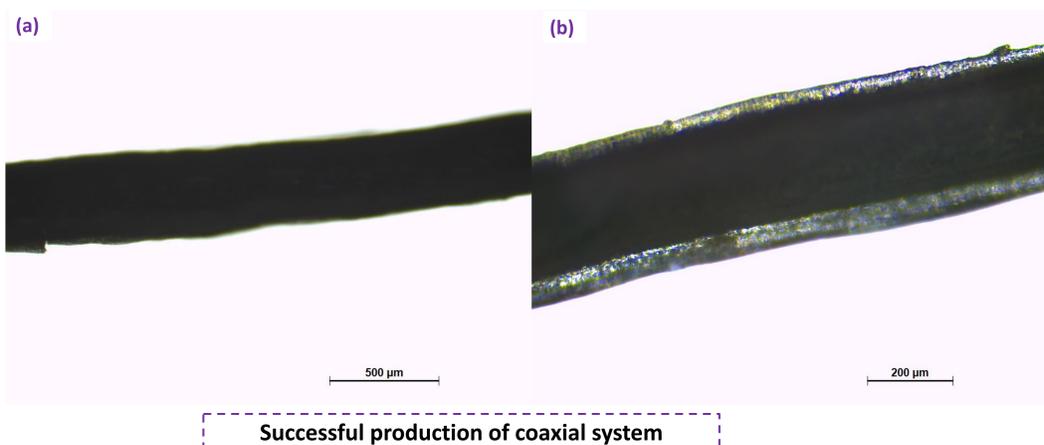
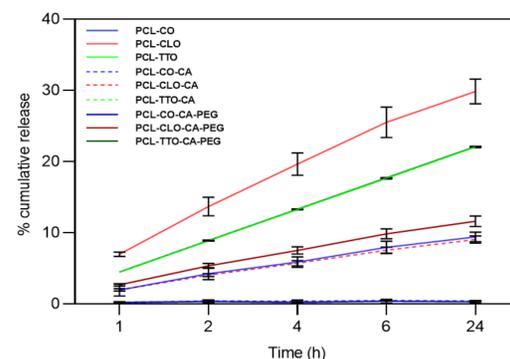


Figure 1. Microscopic observations of (a) monolayered and (b) coaxial wet-spun fibers.

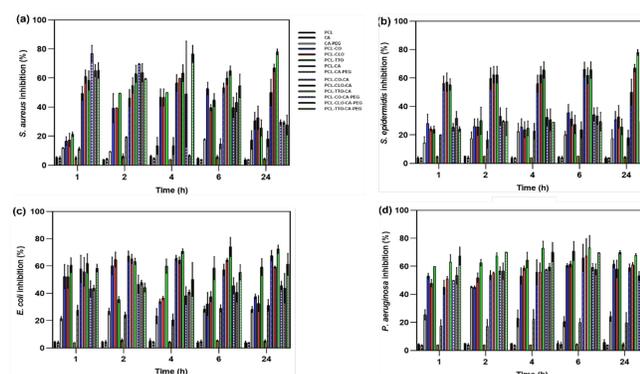
Release kinetics of EOs



All EO-loaded fibers presented controlled and sustained release profiles for the three tested EOs

Figure 2. Cumulative release profile of EO-loaded wet-spun fibers. Data are reported as mean \pm SD (n=3).

Antimicrobial activity



All EO-loaded fibers presented antibacterial properties

Figure 3. Percentages of inhibition of (a) *S. aureus*, (b) *S. epidermidis*, (c) *E. coli* and (d) *P. aeruginosa* bacteria in contact with all wet-spun fibers incubated in PBS for 1, 2, 4, 6 and 24 h. Data are reported as mean \pm SD (n=3).

Conclusions

The potential of the engineered coaxial fibers to serve as controlled release platforms for CO/CLO/TTO was demonstrated, along with their antibacterial activity against *S. aureus*, *S. epidermidis*, *E. coli* and *P. aeruginosa*. Data confirmed the potential of this system to function as a stepwise, pH-triggered delivery platform, suitable for wound healing applications. With this investigation, a step further was taken in establishing wet-spun constructs for drug delivery in CW care.

Acknowledgments

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